# You want to fly What Kind of Hardware?

By:

Keith A Tucker

L. S Gavalas

# Hardware Types

- Hardware Categories
  - Information Technology (Computers: Phones, tablets laptops)
  - Custom Developed
  - General Use: Modified commercial product, referred to as MOTS
  - COTS

- Each category has its own set of challenges.
- Bad news is ISS is filled with requirements that are seemingly designed to only be understood by those extremely close to the program.
- Good news is all categories have seen a relaxing of requirements in general.

# Generic Challenges

- Material Compatibility
  - If the product is extremely small it is not a concern.
  - Stay away from thin brittle plastics
    - If 3D printing Ultem is the only approved plastic.
  - Gels, Solvents:  No alcohols
  - Use conformal coating and treat capacitors as toxic, design to contain.

- Electromagnetic Compatibility
  - Avoid magnets
  - Requirements have heavily relaxed below 100 MHz
  - Start intentional transmitter discussion early.
    - Standard Bluetooth okay

# Generic Challenges

- Batteries
  - Custom battery designs are ill advised.
  - Even COTS solutions must be lot tested
  - Button cells, alkaline have no circuit design constraint, all others do.
  - Do not develop a custom piece of hardware that charges a Lithium cell, testing will destroy multiple units, not just the cell is damaged but the hardware as well.
- Acoustic
  - Stay under NC 34
  - Or 59 dBA, it is limited to 2 hours of operation per 24-hour period
- Microgravity
  - Items with single axis accelerometers are ineffective, Triaxial needed

# Generic Challenges continued

- Structures
  - For portable equipment the only real concern is kick loads.
  - But if the item is controlling a safety hazard, fasteners must be tested.
- Thermal
  - Consider small fans to aid in heat rejection
  - Touch temperature
- Containment: Liquids, Toxins, capacitors etc
  - Tox level hazard dictates the number of redundant levels of containment.
- Servicing of hardware how easily can the hardware be repaired or subcomponents replaced (Orbital Replaceable Unit (ORU))
  - Use of captive fasteners
- Human Factors
  - Usability for a wide range of sizes of humans

# IT Hardware

- The ISS program provides a suite of IT equipment, overall the rationale to fly a custom piece of IT equipment makes this challenging enough.
  - Currently the primary station laptop is a Lenovo T61p model but being changed shortly to a Z-Book.
    - Any attempt to fly a different COTS based solution will be frowned upon.
      - The station community and crew office does wants little variety of products to minimize crew training and maximize throughput.
    - If another asset is required, note no spares will be available in the pantry.
      - Radiation testing of these types of assets is essential to mitigate risks.
      - System must permit remote virus definition updates if any data is to interface with station assets.
  - Suite includes Ipads with different IOS (use of such devices is discouraged)
    - The station architecture due to security requirements does not interface with the apple store
    - If an IOS based device is absolutely essential to your science data gathering work will be required to update the application as certificates and operating systems expire or are upgraded
      - If the application suite requires a server to gather data, minimize interaction with server.

# IT Continued

- If you are flying IT hardware you undoubtedly will be flying software.
  - Software performance requirements are easy.
  - Software documentation and configuration management requirements are arduous.
    - NPR 1750.2 treats all “flight software” as class C or better
      - Previously payload experiment software was class D.

- ISSMP will provide guidance on what the requirements mean and also how to meet their intent with minimum cost.
- PI software development should include the capability  how to downlink data to the ground.

# Custom Developed

- If custom developed hardware is required, emphasis should be on minimizing the crew participation for setup and maintenance.
  - Think automation outside of necessary data gathering
  - Crew training is not necessarily time intensive, and often scheduled many months before flight. Also crew time onboard is at a premium  complicated tasks are hard to plan and impact console support times.
  - Remember that the longer it takes to obtain science data, less chance it will be obtained.
- Custom developed hardware should assume a 2 year development / integration window.
  - With no heritage of COTS, the process of approval of the system through the safety organization is difficult particularly if there is a direct invasive interface with the crew for obtaining crew physiological data.
  - ISSMP participation is needed very early in this development process to assure smooth integration and verification.

# General use MOTS

- General use hardware that has been customized invariably gets labelled at MOTS
  - Asking vendor for custom mods is a great solution.
  - Most vendors will work with us
    - Simple things to consider are
      - Conformal coating, removing paint
    - More complicated items are
      - Replacing connectors to a SCOOP proof variety, changing the housing
      - Consider servicing related changes, like battery change out or cleaning methods
  - The more things done by the manufacturer the better for the overall risk and better warranty support.
    - Avoids questions of tampering or voiding the FDA approval
- This is largely the most flown type of hardware.

# COTS

- For simple projects this is a perfectly fine alternative
- Tremendous upside to buy and fly.
  - Excellent choice for items developed for exercise where a great deal has been invested in the product being ruggedized and weather resistant.
- Many DoD products have been commercialized by vendors, which generally means they sell to aviation and marine communities already
- Be careful of these products in materials compatibility since the ISS environment is very closed loop.

# Why it is best to work with ISSMP Early

- We know:
  - How to make the hardware compatible with current ISSMP hardware.
  - ISS architecture
    - Particular important when designing a pice of hardware to know its use environment.
      - ISS is not like your lab at all.
  - Interfaces:
    - Power is limited to really just 28 V DC and some access is being provided to 120 AC
      - The 120 V AC must be floating neutral compatible, amongst other considerations
      - USB 5Volt power for rapid charging coming in 2017.
    - Data
      - Most like the lab in terms of options; Ethernet(including wireless), USB, Bluetooth and RS - 422.

# Why it is best to work with ISSMP Early

- Why duration from selection to flight is "so long“.
  - Program interfaces
    - Non-HRP payloads have to get a Payload Integration Manager (PIM), we are our own PIM
    - Planning and development for operations and related products
      - Verification plan development, submittals and closure
      - Manifesting
      - Stowage
      - Crew time resources
  - Safety related process
    - 45 days from package submittal to actual review and can be multiple reviews.
  - Human Factors and labelling reviews
  - Certification process
- New development process Class I-E allows faster from ground to flight.

# Good News

- A relatively new development process 1-E allows faster from ground to flight  The new process is for non-critical experiment hardware
  - Allows ISSMP to quickly turn around lab like products to flight products.
    - Relax the detailed drawing requirements
    - Decreases the amount of documentation
    - Allows the procurement from unlimited suppliers (direct from China still not permitted).
    - DOES NOT RELAX SAFETY.
    - Allows direct to lab flight procurements.
    - Effectively takes away the unnecessary NASA slow down of receipt and fabrication
- Near term additions of AC power options
  - Will allow use of standard COTS AC powered items to be flown relatively as is.
    - Must be floating neutral compatible
    - UL listed, with ground wire
    - GFCI compatible

# Requirements

- Most often hardware that is procured or developed by ISSMP is because of clearly defined REQUIREMENTS
  - Clearly defined is not always easy:
    - A product suite that was used in our lab is helpful:
    - Key requirements  for science
      - ISSMP Engineering will take everything else in consideration.
  - ED requirements lead to hardware requirements documents
- Design reviews and Team meetings are your friends
  - Review, evaluate and participate.
    - Compare ED to hardware requirements documents for gaps.
- We deliver 6 months after the final review.
- Science Verfication Test is your final hardware acceptance.

# Take Away

- IT hardware  development is expensive and the use of common IT resources is strongly encouraged.
  - IOS discouraged STRONGLY
  - Deployment and other constraints make stand-alone IT developments challenging
  - If specialty IT hardware is required, avoid a direct interface to ISS avionics environment make it into an embedded system with the rest of the experiment architecture
  - Software best addressed thru a browser based interface
- Repacking COTS devices into a MOTS products is likely best done by the ISSMP team with technical inputs from the PI Team.
- Custom built hardware, after design complete recommend ISSMP personnel build and test flight units as Class I-E.
- COTS hardware best procured and final delivery by ISSMP personnel as Class I-E.
- All softgoods should be planned to be designed and manufactured by ISSMP.

# Things to add

- Pictures